# MICROTOPOGRAPHIC INFLUENCES ON SOIL WATER MOVEMENT

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## INTRODUCTION

Site preparation of pine stands in the Piedmont often results in uneven microtopographic relief. Superimposed onto the macrotopography, microtopographic relief can strongly influence subsurface water content and movement (Keller et al., 1988). This study examines the relationship between microtopographic relief and soil moisture distribution in a loblolly pine plantation in the Piedmont of Georgia. Determination of the spatial distribution of soil moisture requires a topographic scale that encompasses the apparent variability in topography (Burt and Butcher, 1985). Thus microtopographic relief and its potential influence on soil water movement must be examined (Kirkby, 1988). Kirkby and Chorley (1968) identified hillslope hollows as areas where soil water convergence occurs. Soil water movement may be in the form of subsurface lateral flow (Anderson and Burt, 1978) or saturation excess overland flow (Burt and Butcher, 1985).

Microtopographic depressions appear to behave hydrologically like hillslope hollows. Downslope movement of water through the leaf litter, over the soil surface, and laterally through the soil surface horizon could contribute to the concentration of water beneath the depressions. Preferential movement of water through the depressions could strongly influence both chemical and nutrient flux in the solum.

## MATERIALS AND METHODS

In a loblolly pine stand on the University Of Georgia's B.F.Grant Forest chosen for this study, microtopographic features are common. Site preparation and past agricultural practices have superimposed on the landscape a network of closed mini-catchments. Twenty years of pines have resulted in the stabilization of these features on a highly eroded upland piedmont Cecil soil. The mini-catchments, depressions and their associated ridges, range from one to several meters across and to 25 cm deep.

Soil volumetric moisture content is monitored using Time-Domain Reflectometry (TDR). A series of 21 permanently installed rod pairs of lengths 20, 40 and 60 cm transect five depressions. The tops of the rods are flush with the mineral soil's surface. Coaxial cable two meters in length connects each rod pair to a phenolic rotary switch protected from moisture in a plastic food storage container. The switching system allows quick measurements using a Tektronix Model 1502 Cable Tester. Additionally, degradation of the natural conditions associated with heavy foot traffic and frequent measurements is eliminated. Vertical rod pairs of 25 and 50 cm lengths are employed to monitor soil volumetric moisture across two ridges. Permanently installed and connected with a hand-held cable, rod pairs 20 cm apart transect the ridges and their sideslopes.

Rod readings are made before and after each storm to compare the response of the depression to their associated ridges. Soil volumetric moisture content has been continually monitored at the site beginning in August, 1988. Because of the continuing drought in the southeast long periods of drying have been recorded interspersed with occasional periods of soil wetting. Soil volumetric moisture content is calculated using Topp's calibration curve (Topp and Davis, 1985) and converted to the volumetric moisture content for each 20 or 25 cm increment of depth. Rod pairs of 20 and 25 cm length record the changes in the soil's A horizon. The calculated 40 to 60 cm increment represents changes in the upper part of the $B_t$ horizon. Because of the variability inherent in a highly disturbed Cecil soil, the 20 to 40 cm depth represents the lower A, the upper $B_t$ and/or a transition horizon between the two horizons.

Soil suction is monitored using sixteen tensiometers placed in groups of four along the top of two ridges and in two adjacent depressions. Measurements are made at 15 minute intervals and datalogged. Each group contains tensiometers at depths 15, 30, 60 and 90 cm.

Concurrent studies at the site gather relevant meteorological data.

## DISCUSSION OF RESULTS

Microtopographic depressions favor the concentration of water in the soil beneath the depressions. Enhanced volumetric moisture content is observed beneath the depressions for storms of varying intensity and duration. Lateral movement of water through the leaf litter and through the soil preferentially redistribute the moisture.

Leaf litter, primarily composed of loblolly pine needles, is distributed unevenly across the soil surface. Mechanical redistribution of the litter and varying rates of decomposition have produced thicker organic horizons in the depressions. Orientation of the litter across the microtopographic relief favors the lateral movement of water downslope through the litter. Rains of less than 0.3 inch result in little or no change in soil moisture content on the ridge. Storms as small as 0.1 inch result in soil moisture content changes beneath the depressions. In the depression, change in water content as deep as the upper $B_t$ horizon may be observed when little change is recorded on the ridge for these small events.

Rains of 0.5 inch or greater results in volumetric moisture content changes across the microtopographic relief. However, changes in soil moisture beneath the depression may be twice that of the ridges in the surface horizons. Changes in the $B_t$

horizon are not as dramatic. Macropore flow may account for rapid movement deeper into the profile frequently recorded for larger storms. No ponding in the depressions has been observed.

The drought conditions in this region of Georgia have provided a unique opportunity for the study of soil response to precipitation. Infrequent rains followed by long dry periods provide for the observation of each storm in isolation. After periods of little or no rainfall, the soil volumetric moisture content becomes uniform across the topography, and near uniform by soil horizon. Subsequent rains produce a topographic dependent response in the soil volumetric moisture content. Enhanced wetting is observed beneath the depressions, followed by an enhanced rate of drying, particularly during the growing season and warm winter days. The rate of change of soil moisture during the drying cycle is greatest beneath the depressions indicating greater root activity in this region. Root distribution in this Cecil soil is apparently influenced by the microtopographic relief.

The pattern of redistribution of water with depth over time after rain is apparent in the TDR data. Wetting of the surface horizon while the $B_t$ continues to dry is common for light rains. Larger storms that result in near saturated conditions in the surface horizon can be traced with time as the surface begins to dry and the $B_t$ horizon wets.

Textural analysis across the microtopographic relief shows no variation outside the expected variability in the soil. Pore size distribution and total void space are assumed to be uniform across the relief.

## SUMMARY

Agricultural and forestry practices often produce microtopographic relief. In site prepared pine stands of the piedmont of Georgia, this type of relief is common. In other areas, for example, mountainous hillslopes, variation in microtopographic relief may be extensive. Soil moisture content is influenced by this relief. Mechanisms of redistribution result in enhanced movement of water into and through the soil beneath microtopographic depressions. Enhanced wetting and drying cycles indicates that the impact of microtopography on physical and chemical activity in the soil warrants further investigation. Nutrients and ions of atmospheric deposition could strongly be influenced by the preferential movement of soil water.

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